NIMA's Needs for Astrometric Data

Mr. Stephen Malys
Dr. William Stein
National Imagery and Mapping Agency (NIMA)
Research and Technology Office
Bethesda, MD

resented at the USNO Astrometry Forum, 5-6 December, 20

National Imagery and Mapping Agency

- NIMA Mission: Provide timely, relevant, and accurate imagery, imagery intelligence, and geospatial information in support of national security objectives

- NIMA Vision: Guaranteeing the Information Edge

- Our information provides the common reference framework for planning, decisions, and actions

  - World Geodetic System 1984
    - Earth-Centered, Earth Fixed Reference Frame, Coherent Collection of Models
    - Refined to be as Closely Coincident as Possible with the International Standards (IERS/ITRF)
  - Target Location for Numerous Weapons Systems
  - Support Data for Inertial Navigation Systems

Outline

- Satellite Orbit Determination
- Satellite Attitude Determination
- Astrogeodetic Surveying
  - Definition: Deflections of the Vertical
  - Support to B2, F117 Inertial Navigation Systems
  - Support to Launch Vehicles, ICBMs, SLBMs
  - Monitor Deformations of Holloman High Speed Test Track, Support INS testing of Vehicles on Track
- Summary

Satellite Orbit Determination

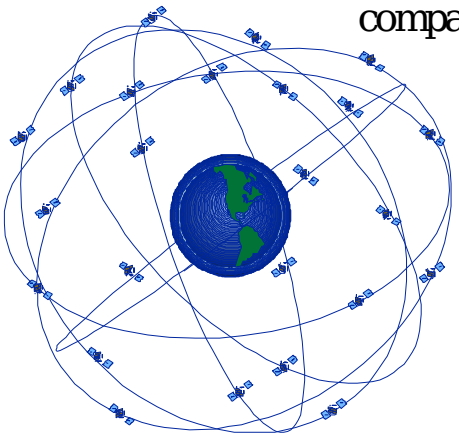
- Transformations between ECI (J2000) and ECEF (WGS 84) Reference Frames are required for all operational orbit determination processes for satellites of interest to NIMA
  - Precession
  - Nutation
  - Earth Orientation Predictions
    - Polar Motion (X_p, Y_p)
    - UT1-UTC

NIMA Earth Orientation Specs

NIMA EOP Service Established in 1984

MOU Established Between NIMA and USNO, September 2000

Specs in ICD-GPS-211, Revision B, 5 February 1999



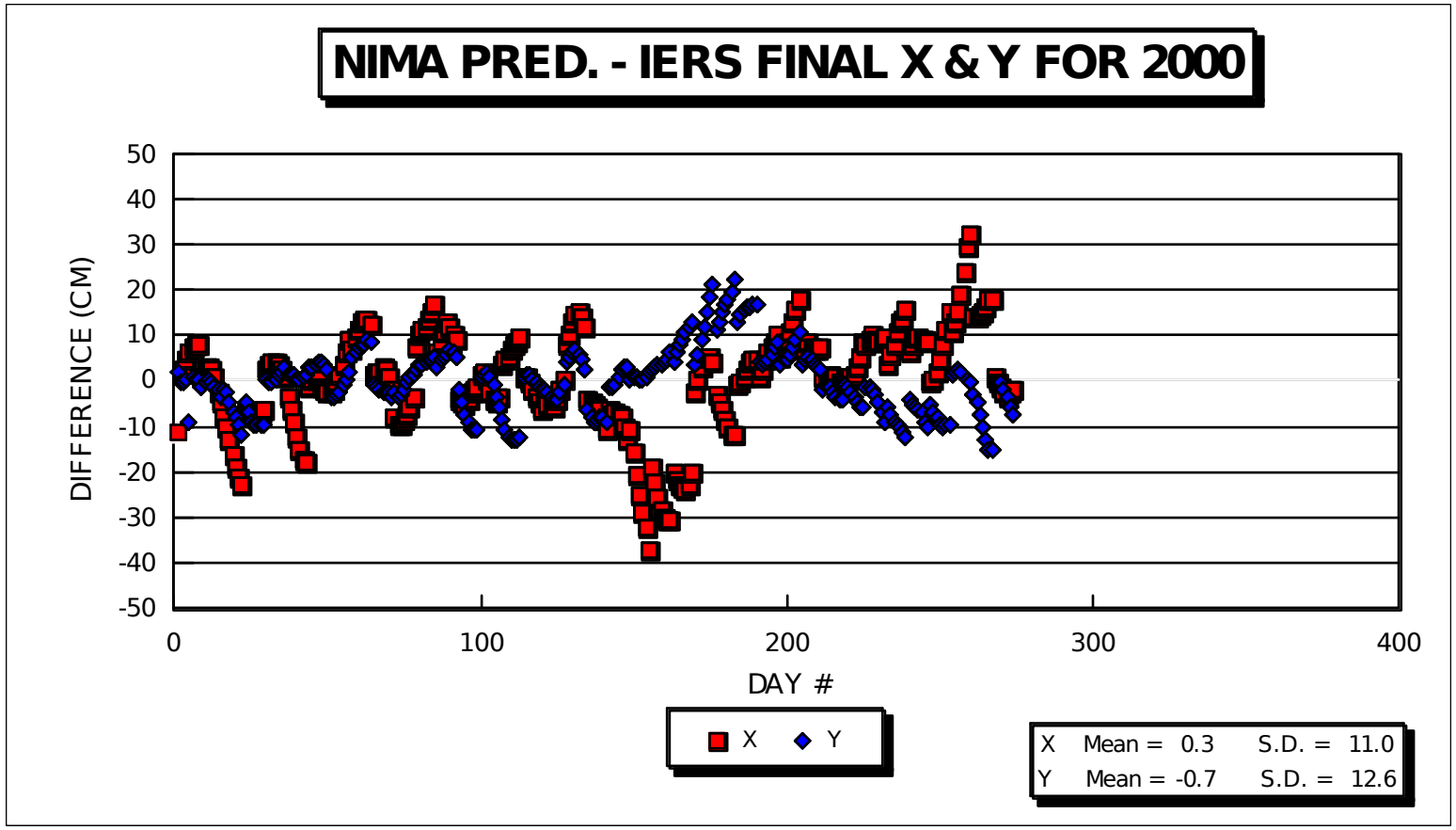
The polar parameter predictions provided by NIMA referenced to the effectivity day will compare to the IERS finals at the 1 sigma level as shown below:

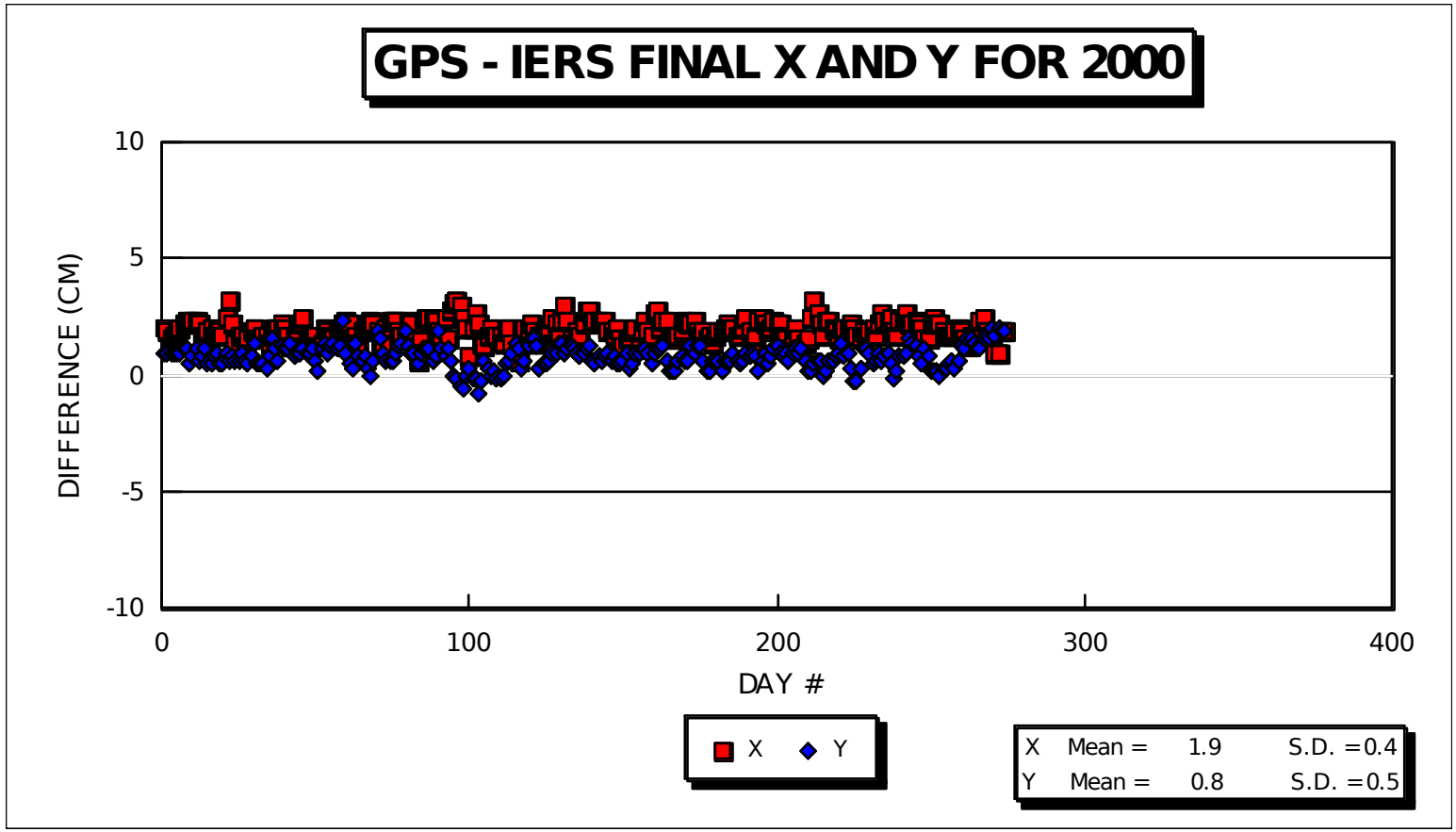
	X and Y Components	UT1-UTC
1 day	3 mas	3 ms
7 day	7 mas	5 ms
14 day	10 mas	7 ms
35 day	15 mas	12 ms
180 day	40 mas	60 ms

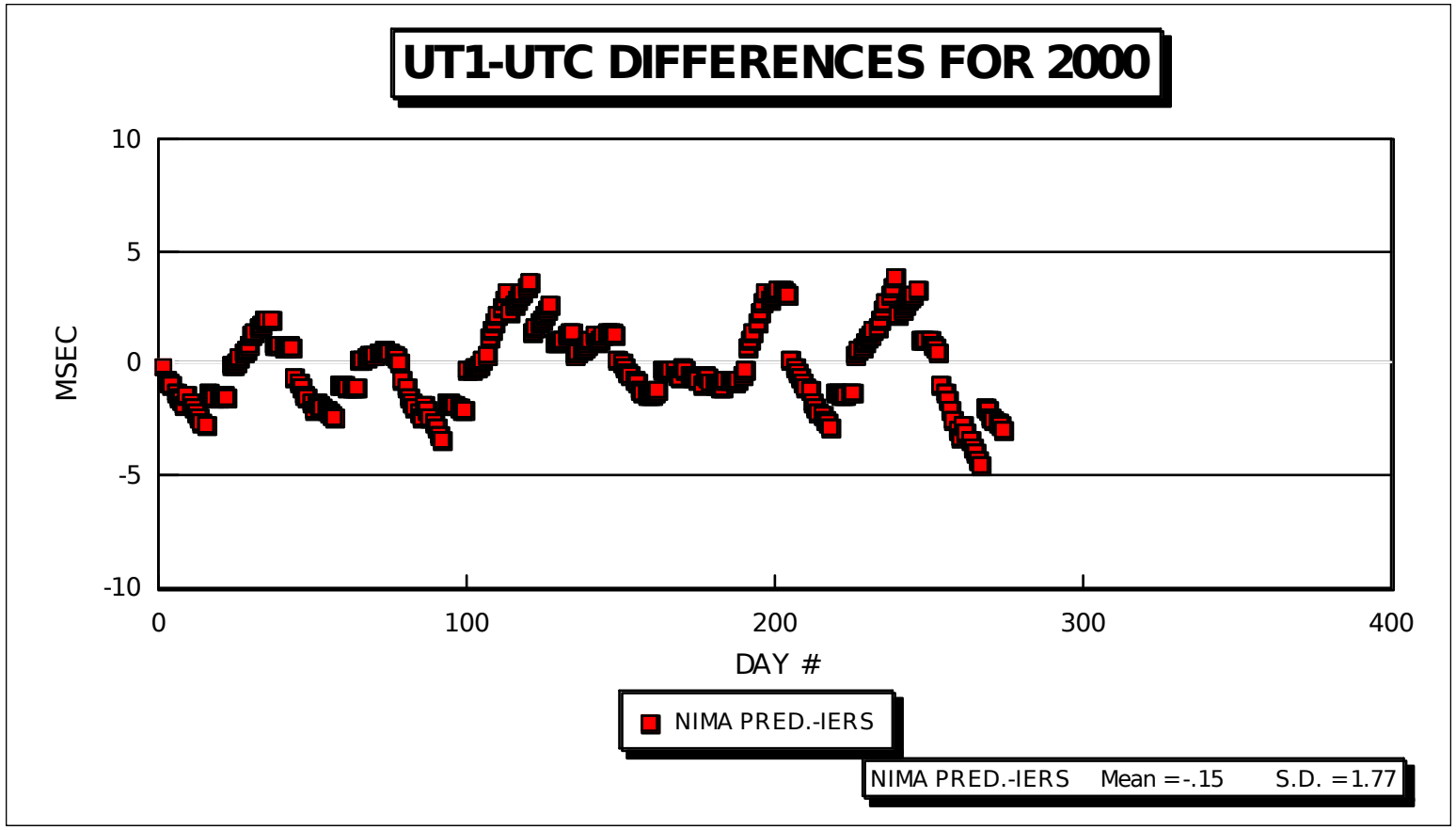
Previous specs were

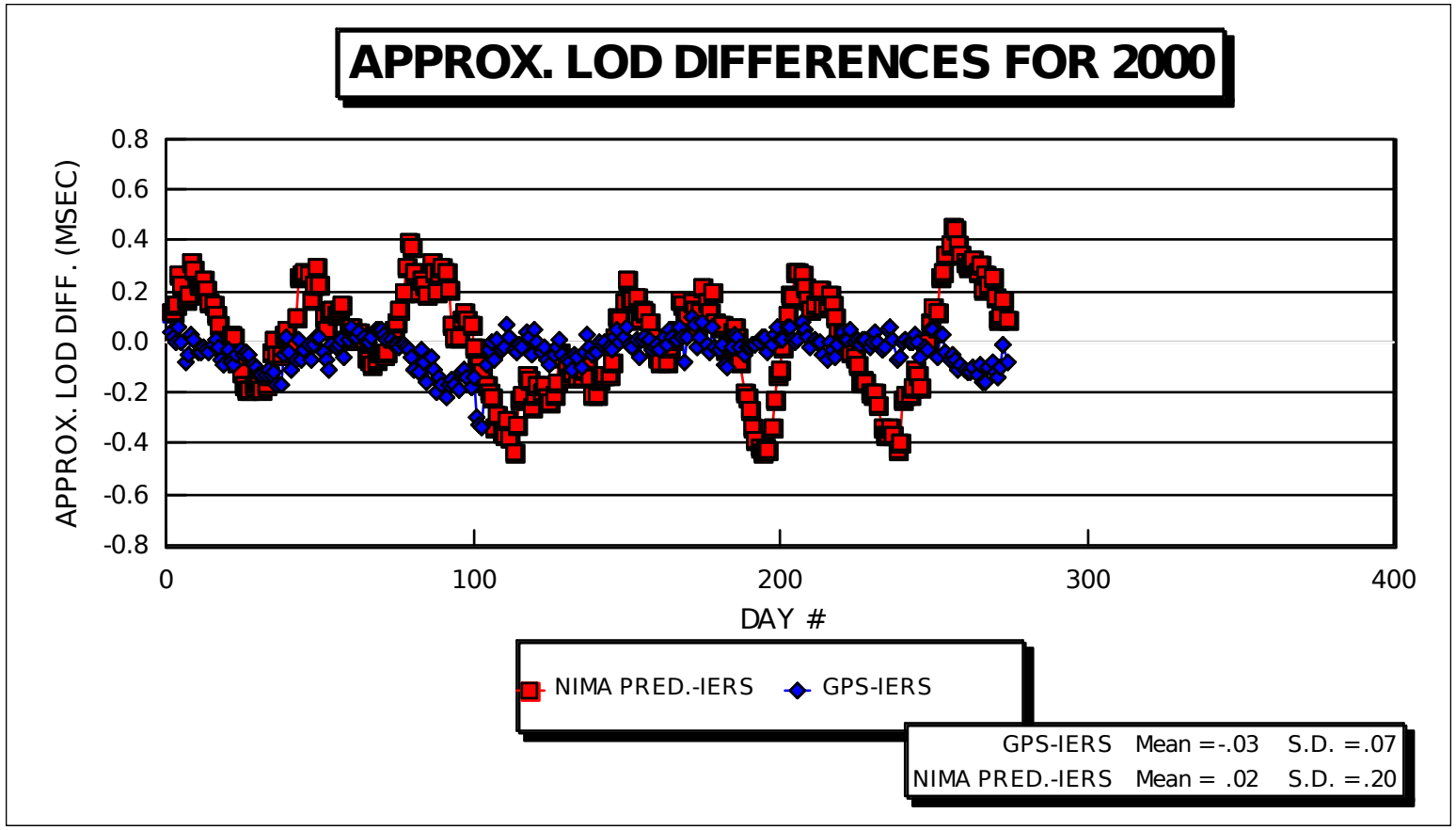
1 sigma at 15days: X and Y Pole: 0.015 arc sec, UT1-UTC: 0.006 sec

1 sigma at 5 weeks: X and Y Pole: 0.035 arc sec, UT1-UTC: 0.011 sec

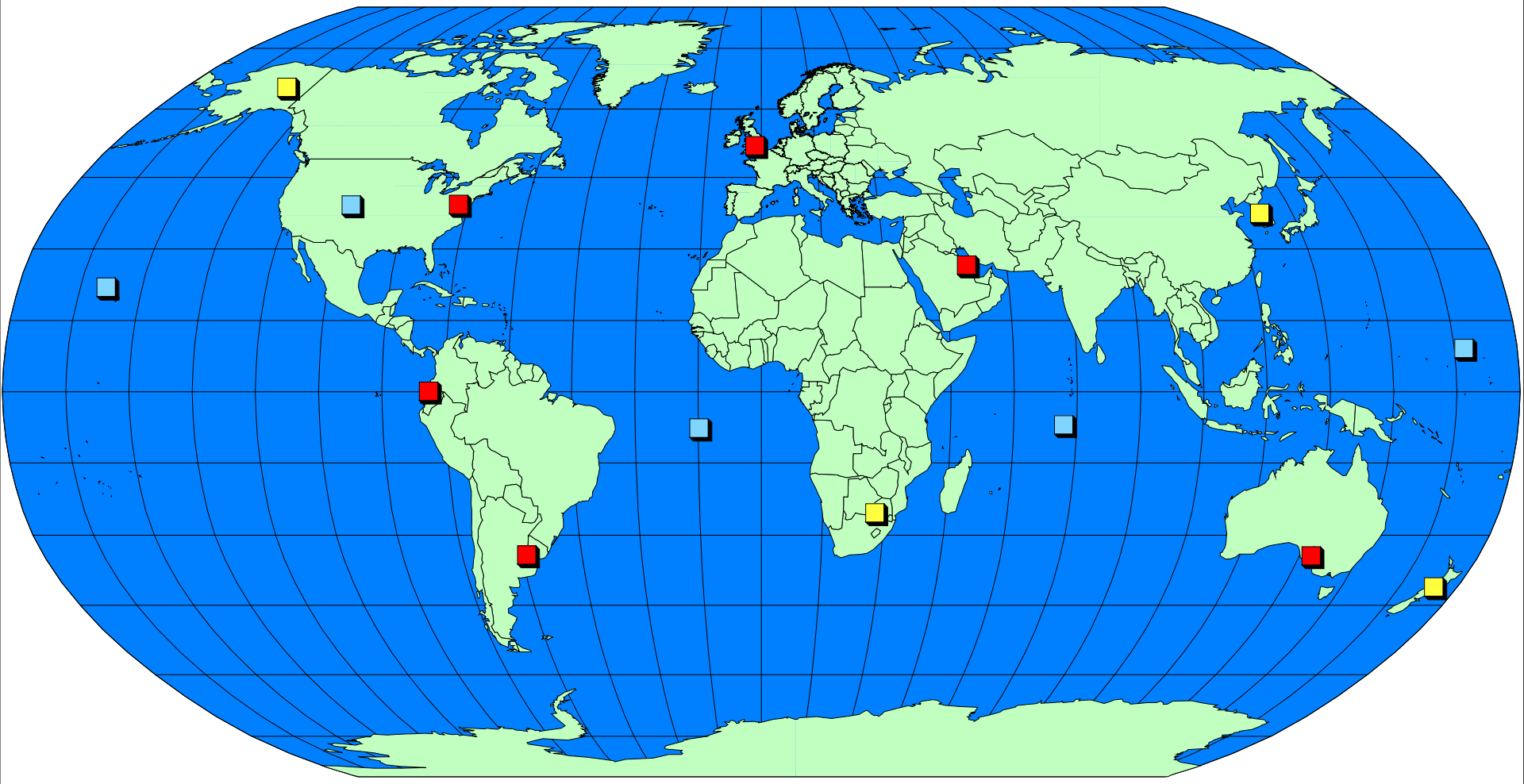

NIMA PRED. - IERS FINAL X & Y FOR 2000
DIFFERENCE (CM)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0
100
200
300
400
DAY #
X
Y
X Mean = 0.3 S.D. = 11.0
Y Mean = -0.7 S.D. = 12.6


GPS - IERS FINAL X AND Y FOR 2000
DIFFERENCE (CM)
10
5
0
-5
-10
0
100
200
300
400
DAY #
X
Y
X Mean = 1.9 S.D. =0.4
Y Mean = 0.8 S.D. =0.5


UT1-UTC DIFFERENCES FOR 2000
10
5
0
-5
-10
MSEC
0
100
200
300
400
DAY #
NIMA PRED.-IERS
NIMA PRED.-IERS Mean =-.15 S.D. =1.77


APPROX. LOD DIFFERENCES FOR 2000
APPROX. LOD DIFF. (MSEC)
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
0
100
200
300
400
DAY #
NIMA PRED.-IERS
GPS-IERS
GPS-IERS Mean =-.03 S.D. =.07
NIMA PRED.-IERS Mean = .02 S.D. =.20

DoD GPS Tracking Network

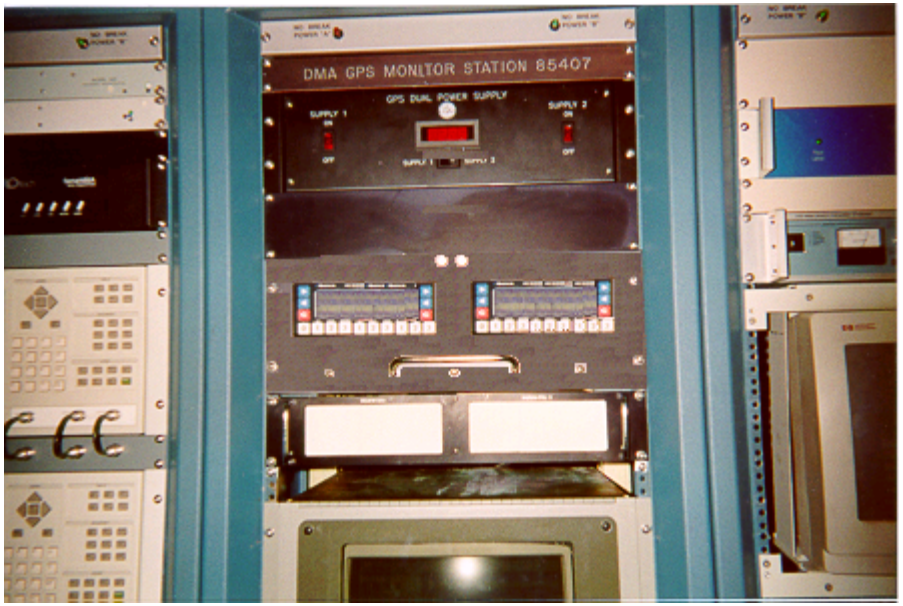


Air Force Monitor Station

NIMA AII Station

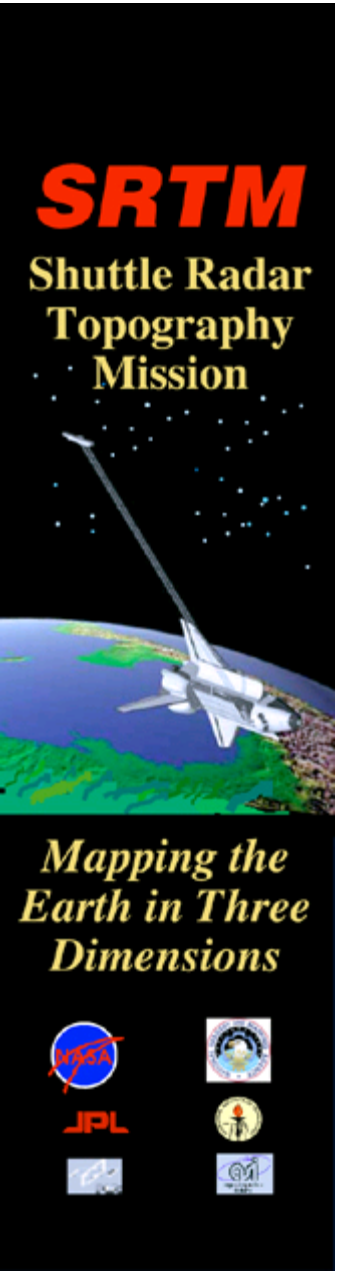
NIMA Station

NIMA GPS Tracking Station at USNO



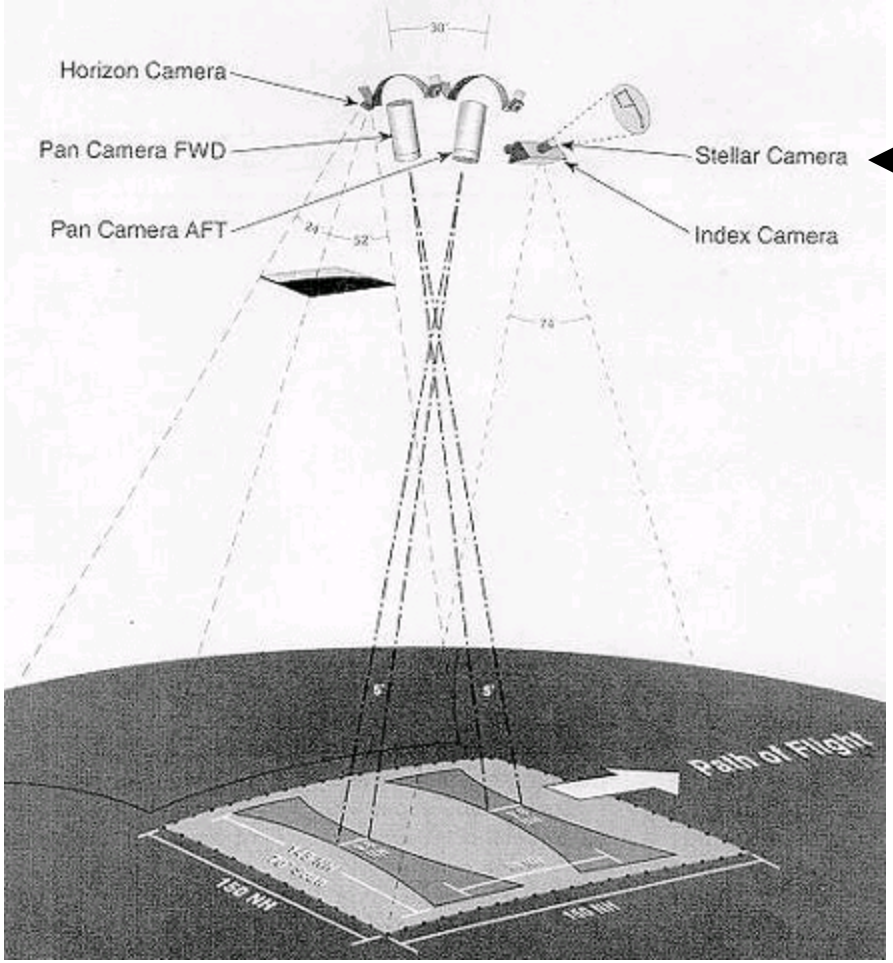
The NIMA GPS Tracking Station at USNO uses a frequency standard tied to UTC(USNO)

Satellite Attitude Determination



- A number of Imaging Platforms used by NIMA Require the Use of Accurate Star Catalogs in the Attitude Determination Process
  - Attitude Determination Accuracy Can be a Significant Factor in the 'Geopositioning' Error Budget

A Piece of NRO History- The Corona Program



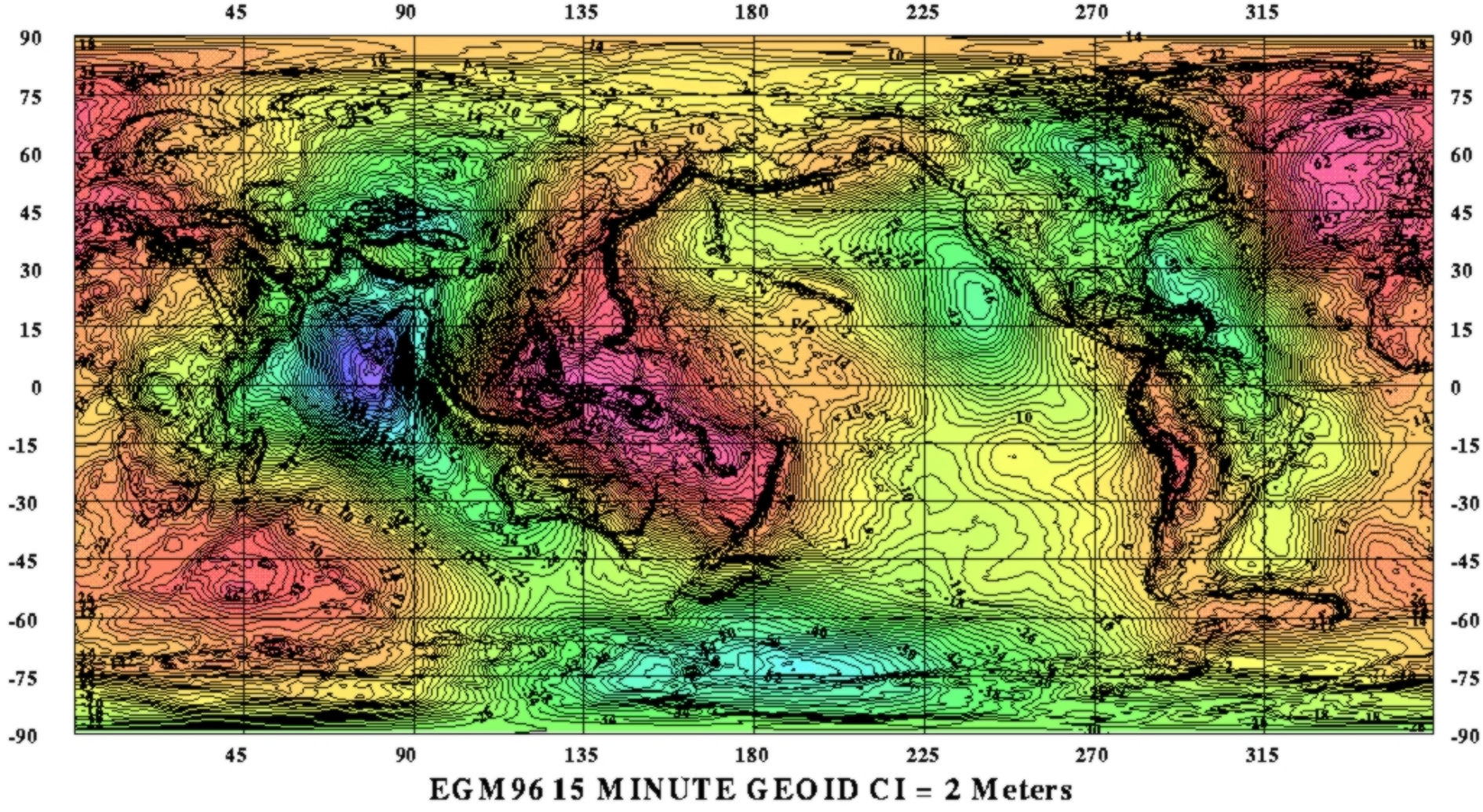
Note the ‘Stellar Camera’

Operational: 1960-1972

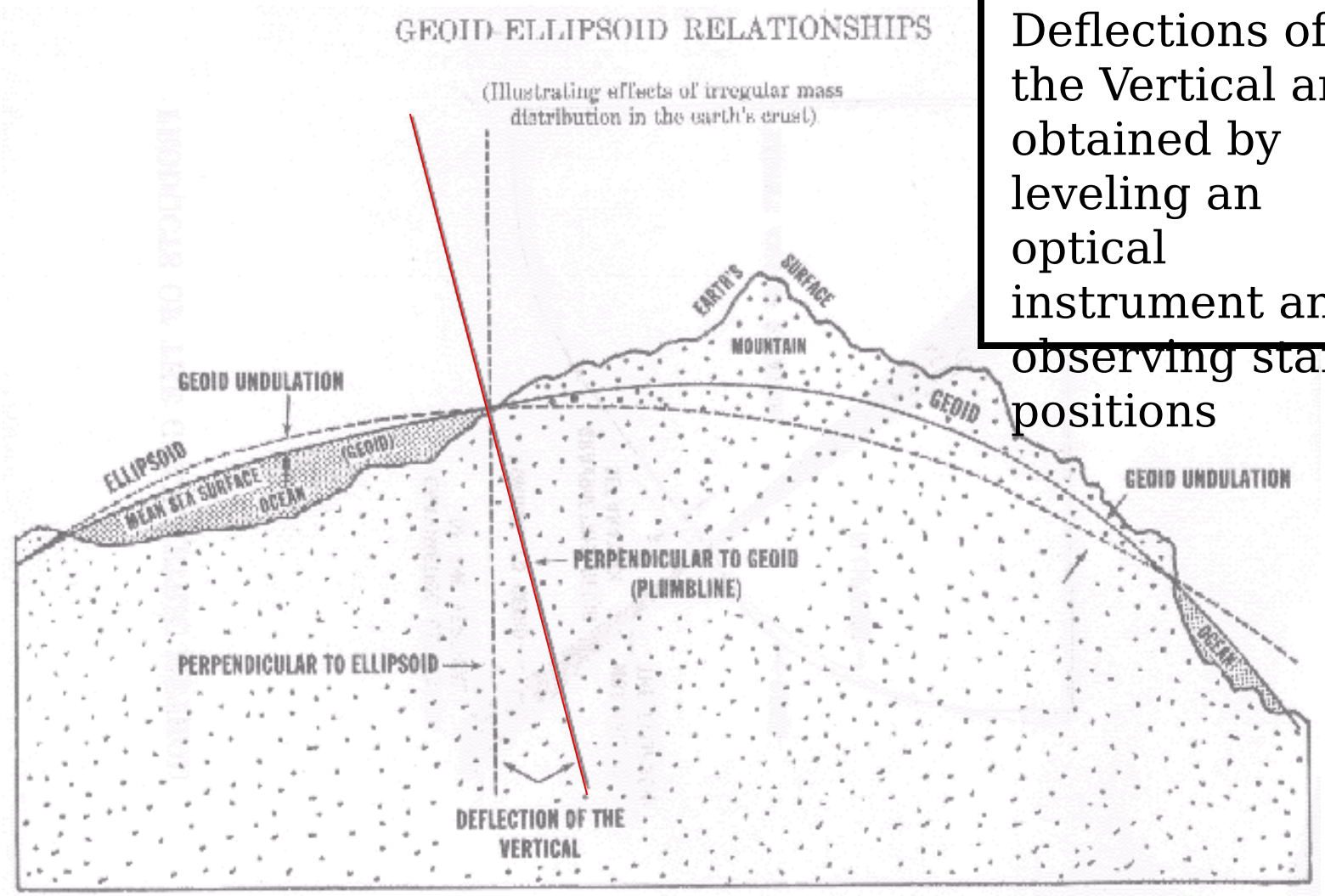
~~Declassified: 1995~~

More info:
http://www.nro.gov/index1.html

Earth Gravitational Model 1996 (EGM96)



Astrogeodetic Surveying

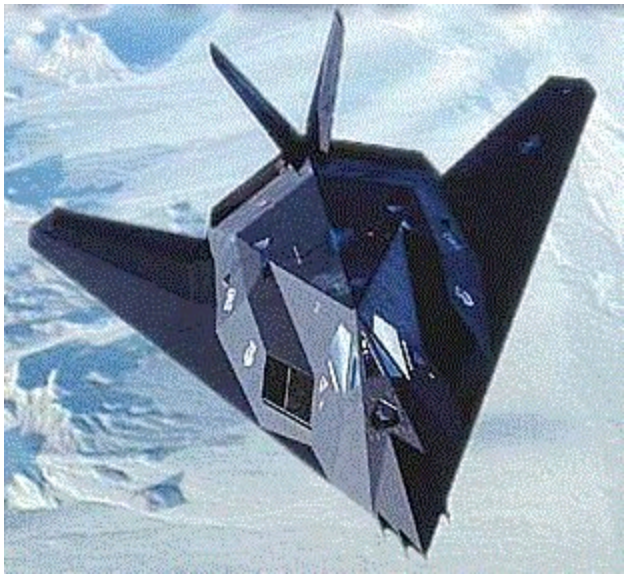


Deflections of the Vertical are obtained by leveling an optical instrument and observing star positions

NIMA Astrogeodetic Surveying

- A35M Astrolabe
- Three Built for NIMA by Physical Sciences Lab of New Mexico State U
  - Mercury Pool Reflector
  - Uses FK5 + ‘Supplemental’ Star Catalog
- Routine Astronomic Position Accuracy of 0.10 Arc Sec
- Routine Deflection of the Vertical Accuracy of 0.20 Arc Sec

Inertial Navigation Systems Require Deflections of the Vertical During Initialization Process



Improved Astrometric Products Support Improved Target Location Accuracy and Weapons Delivery Accuracy

Astrogeodetic Surveying Supports All Launch Vehicles and ICBMs

Atlas

Minute Man

Astrogeodetic Surveying Supports All Launch Vehicles

Delta

Titan

Holloman AFB High Speed Test Track

- 50,788 feet of precisely aligned, continuously welded rail
- Contains areas for impact, blast, crew egress, and rainfield testing
- The master rail is aligned within 0.005 inches with respect to a reference (fiducial) line established with better than first order accuracy over its nearly 10 mile length
- Small payloads (100 lbs) have reached Mach 8 while large payloads (20,000 lbs) can reach Mach 1
- Accelerations up to 200g have been realized.
- The track provides telemetry/onboard recording and photo-optical support for tests
- NIMA Monitors the Track Alignment, in part by Performing Periodic Astrogeodetic Surveys at 32 Astro Stations Located Adjacent to the Track

Summary

- NIMA Depends on Astrometric Data for a Number of Geopositioning Applications
  - High-Accuracy Satellite Orbit Determination
  - High-Accuracy Satellite Attitude Determination
  - Astrogeodetic Surveying in Support of
    - B2 and F117 and Other Aircraft
    - Numerous Launch Vehicles, ICBMs, SLBMs
    - The Holloman High-Speed Test Track